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ABSTRACT

A review of recent major studies of two-year college developmental mathematics programs shows that there has been much experimentation in curricular offerings, course formats, and instructional approaches, including expanded content related to the students' major fields, and the use of short courses and mini-courses. However, while many instructors are experimenting with new approaches, the traditional classroom-lecture-textbook format remains the dominant mode of instruction. In addition, most programs rely on voluntary enrollment by students rather than outreach or recruitment and instructors are frequently assigned by random selection and rotation. Considerable inconsistency exists in college policies regarding the granting of academic credit for these remedial courses, with one study reporting two-thirds of nationwide community colleges offering credit. Two-year colleges need to design developmental programs to deal effectively with such problems as widespread avoidance of basic mathematics by students, inadequate achievement levels, and high attrition rates. In an effort to increase the effectiveness of their programs, colleges should consider the use of highly motivated and interested instructors, special preparatory training for these instructors, support for teachers to develop innovative instructional methods and materials, and close evaluation of remedial mathematics programs. (DR)

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JUNIOR COLLEGE RESOURCE REVIEW

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DEVELOPMENTAL MATHEMATICS

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ERIC CLEARINGHOUSE FOR JUNIOR COLLEGES

Arthur M. Cohen, Principal Investigator and Director

DEVELOPMENTAL MATHEMATICS

The number of two-year college students requiring instruction in pre-college mathematics has increased dramatically (Lindberg, 1976). Several recently completed surveys report that developmental math courses (e.g., arithmetic, pre-algebra, elementary algebra, geometry) are now offered in over 95 percent of America's two-year colleges, and that these preparatory courses account for a significant part of the instructional effort of most mathematics departments (Lindberg, 1976; Beckwith, 1979).

Course and program planning for educationally underprepared students is affected by several considerations. First, a high percentage of college students, at all levels, have trouble successfully completing mathematics courses. This is especially true in the community college where the attrition rate in a typical mathematics course often runs between 40 and 60 percent (Stein, 1973). Second, research studies have shown that many underprepared students enter college with a legacy of content deficiencies, weak study habits, poor self-image, diffused goals, unsuccessful learning experiences, and a dislike for mathematics (Baldwin and Others, 1975). These weaknesses are compounded by poor verbal skills (Bittinger, 1972). Third, universally successful teaching materials and methods are not available. The students who must be taught are so varied that any one set of procedures is doomed to fail for at least a number of them.

How are community colleges responding to these rather formidable challenges to the successful design and implementation of their developmental mathematics programs? This issue of *ERIC Junior College Resource Review* summarizes results reported in major state, regional, and national surveys of developmental mathematics programs. Course offerings, assigning students to classes, awarding credits and grades, instructional methods, evaluation of program effectiveness and procedures for selecting faculty to teach the courses will be presented.

What Courses Are Offered?

Surveys concerned with curriculum in developmental mathematics programs have focused on such issues as types of courses taught (Beal, 1970; Baldwin, 1974; Baldwin and Others, 1975; Lindberg, 1976; Brawer and Friedlander, 1979), enrollments (Beal, 1970; Fey and Others, 1976; Lindberg, 1976; American Mathematical Society, 1977), course content (Friesen, 1974), where students report for instruction (Baldwin and Others, 1975; Beckwith, 1979), and departments administering developmental mathematics programs (Baldwin, 1974; Baldwin and Others, 1975).

The results of a nationwide survey of two-year colleges by Baldwin and Others (1975) showed that the two most widely offered remedial mathematics courses were elementary algebra (89%) and arithmetic (84%). These were followed by geometry (35%), trigonometry (34%), and a category labeled "other" (29%) which included courses concerned with such topics as slide rule, metric system, basic and technical statistics, and technical algebra. Over half of the colleges offered either one or two developmental mathematics courses.

Several commentators have recommended that instructors make a special effort to expose students to the areas of remedial mathematics most closely related to their intended major or career choice (Ohlmeier, 1972; Friesen, 1974; Willcox, 1977). Baldwin and Others (1975) found that just under one-third of the colleges in their survey varied the required content of their developmental mathematics courses for each student, depending on the student's major course of study. An interesting approach for exposing students to those areas of mathematics that each individual would find most useful has been developed by Bator County College in Kansas (Ohlmeier, 1972). Here the Mathematics Department has implemented a variety of short courses each taught for a five-week period and counted as one hour of credit. These mini-courses meet for 150 minutes each week. The students, with the help of their advisors, enroll in those mini-courses that are most closely related to their intended major or career choice (Friesen, 1974).

How Are Students Assigned to Courses?

Research on the placement of students into developmental mathematics courses has been concerned with such questions as: What methods, if any, are used to select students for enrollment in remedial courses? Are those students who have been determined to be mathematically deficient required to enroll in a remedial course? And, once placed in a remedial course, are diagnostic procedures maintained? (Beal, 1970; Muir, 1973; Baldwin, 1974; Baldwin and Others, 1975; Friesen, 1974; Pearlman, 1977).

Baldwin and Others (1975) found that the most popular methods used to select students to participate in developmental programs were voluntary enrollment by the students (53%), high school grades in mathematics (53%), interviews (45%), teacher referral (44%), and department placement tests (28%). Standardized commercial placement tests (e.g., SAT, ACT) were used in only 20 percent of the colleges. The authors recommended that placement procedures in all colleges should be expanded to include more than just high school mathematics grades; they should include placement tests. A similar recommendation came from a study of remedial mathematics programs in New York State (Baldwin, 1974) where it was learned that although only 38 percent of the schools used a placement examination, 71 percent of the chairpersons felt it ought to be used. Several examples of programs in which tests are used for placement can be found in articles by Stein (1973), Horner (1974), and Zwerling (1977).

Credits and Grades

The problem of whether college credit should be granted for work left undone in high school has been the subject of much debate. Surveys show that there is much inconsistency among colleges in their policies of awarding college credit for remedial courses. In fact, policies concerning whether students should receive credit — and if so, how much — for completing remedial mathematics courses were found to vary widely among colleges in the same system. Muir (1973) found that one-half of New York's eight community colleges did not offer

credit for remedial courses. Among those colleges that did offer credit, there were often substantial differences in the number of units awarded for completion of essentially the same course.

Findings obtained from two nationwide studies (Baldwin and Others, 1975; Lindberg, 1976) revealed that approximately two-thirds of the community colleges offered credit for their remedial mathematics courses. However, many of these colleges did not count the credits earned in remedial courses toward fulfillment of their mathematics degree requirements.

Half the chairpersons in Baldwin's study felt that elective credit for remedial courses should be granted, but such credit should not be used to fulfill their school's mathematics requirement. An additional 31 percent of the respondents did not believe college credit should be awarded for remedial work. However, a college's policy concerning the granting of credit — full, restricted, anything else — should be considered in terms of the possible effects on student motivation to enroll, to persist, and to invest the necessary amount of effort to do well in these courses. A somewhat similar concern was voiced by Muir (1973) who noted that attrition rates may be higher and attendance levels lower when courses are not credited.

Baldwin and Others (1975) found that the traditional letter grade was awarded to students completing a remedial mathematics course in two-thirds of the colleges. Pass-fail, pass-no-credit, or some variation of the pass-fail-incomplete option were assigned to students in the remaining schools. Similar results were obtained in the survey by the Center for the Study of Community Colleges (Beckwith, 1979). Close to 60 percent of the respondents in Baldwin's (1974) New York State two-year college sample felt that ideally the grading system would be a variation of the pass-fail system. However, others (Perry, 1971) noted that such a policy may present a problem for students when transferring to a four-year institution.

How Are Courses Presented?

Much of the literature on developmental mathematics is comprised of essays describing the instructional methods used by a faculty member or department at a particular two-year college. Although innovative instructional methods are being developed and tried out by many instructors, results reported in several recently completed nationwide surveys consistently show that by far the largest percentage of developmental mathematics courses are still taught by the traditional lecture-discussion method (Friesen, 1974; Baldwin and Others, 1975; Lindberg, 1976; Beckwith, 1979).

Lindberg (1976) found that 84 percent of the two-year colleges in his sample used a traditional lecture format to present their remedial mathematics courses. At 30 percent of the colleges students were provided with the option of studying individually with self-guided materials or enrolling in a traditional lecture class. An additional nine percent of the colleges offered courses which combined traditional lectures with individualized instruction. The investigator was also interested in learning how the developmental courses were organized. Here he found that close to 60 percent of the remedial mathematics classes had a traditional classroom organization where the pace was essentially predetermined and student credits (grades) were based on overall performance during the term. A lecture format was employed in about 90 percent of these classes.

Just over one-third of the remedial mathematics courses were designed along the lines of a mastery learning approach. The subject areas to be covered in these courses were divided into a set or sequence of learning units, and the amount of time spent on each unit was flexible, depending on the grade desired and/or the level of performance required. The mastery

learning approach combined with individual self-paced instructional techniques (e.g., audio-tutorial, Keller Plan, laboratory approach, programmed instruction) were featured in 23 percent of the courses surveyed by Lindberg (1976) who found that the respondents' perception of the success of their program was related to the manner in which the courses were presented (lecture vs. individualized instruction) and the way in which they were organized (traditional vs. mastery learning). Programs were judged to be more meaningful where individualized instruction and mastery learning techniques were used instead of programs where lecture formats and traditional classroom organization were relied upon. Alternative approaches to the straight lecture include (in approximate order of popularity) programmed texts, tutoring, mathematics laboratories, independent studies, and mini-courses (Pearlman, 1977).

Expecting that the methods would have varying degrees of effectiveness in terms of academic achievement, persistence, and attitudes towards mathematics, many researchers have conducted studies to determine the merits of each approach. Much of the research on the relative effectiveness of different instructional strategies that have been tried in two-year college remedial mathematics courses is summarized in papers prepared by Nott (1971), Schoen (1976), Pearlman (1977), and Ajose (1978). An extensive review of research on instructional methods at community colleges can be found in an article written by Berry (1978). Studies of individualized instruction, programmed instruction and computer applications, media approaches, affective approaches, student-faculty interaction, and peer tutoring are discussed. Descriptions of the rationale underlying several of these innovative methods are also presented.

Ajose (1978) reviewed some 30 studies — many of which were dissertations — on the relative effectiveness of 16 different instructional strategies that were used to varying degrees in two-year college remedial mathematics courses. With the exception of mastery learning, the findings of these studies failed to provide any consistent evidence that individualized instructional methods (e.g., programmed learning, audio-tutorial, contract method, tutorial approach, televised instruction) when compared to the traditional classroom lecture method resulted in more achievement or in lower attrition rates. These findings are generally in line with those reported by other investigators who have surveyed the research in this area. However, results reported in several studies indicated that tutoring students, using lecture-demonstration methods, small group instruction, or mastery learning approach could improve student attitudes toward mathematics (Ajose, 1978). Perhaps, as suggested by Pearlman (1977), Berry (1978), and Ajose (1978), a more effective approach to presenting developmental mathematics would be to use a variety of learning techniques, that is, combining the advantages of lecture with that of controlled, self-paced instruction.

How Effective Are Developmental Mathematics Programs?

A number of commentators have voiced concern over the lack of systematic efforts to evaluate the effectiveness of developmental mathematics programs (Beal, 1970; Muir, 1973; Baldwin, 1974; Baldwin and Others, 1975; Ajose, 1978). To illustrate, Baldwin and Others (1975) found that the developmental mathematics programs in 72 percent of the colleges surveyed had not been formally evaluated. Lindberg (1976) was interested in identifying the criteria upon which remedial mathematics programs were evaluated. Results of his study revealed that evaluations were based on completion rates (42%), achievement in subsequent courses (38%), student attitudes (32%), faculty attitudes (21%), and the number of drops or failures (19%).

Who Teaches Developmental Mathematics?

Surveys in the field of developmental mathematics have included questions on the instructors' educational preparation, attitudes on teaching remedial courses, and suggestions on how developmental mathematics can be improved.

Beal (1970) and Baldwin and Others (1975) were interested in learning how instructors were chosen to become involved in their college's remedial program. Results obtained from their national samples of community colleges revealed that the methods most commonly used to choose instructors for remedial programs were random selection and rotation. These were followed by instructors volunteering to teach the courses and by hiring other instructors specifically to teach in this area. Beal (1970) questioned the educational wisdom of assigning instructors to teach remedial mathematics regardless of their interests.

The appropriateness of the educational preparation of two-year college mathematics instructors was the subject of a recently completed study conducted by McKelvey and Others (1979). The investigators found that, in general, the present two-year college mathematics teacher — like their colleagues in four-year colleges and universities — were trained in pure math and this included those with degrees in mathematics education. Not surprisingly, most of the instructors who responded to this survey indicated that they had no formal training in the teaching of remedial courses, especially in arithmetic. Two-thirds or more of these instructors recommended that the educational component of advanced training programs in mathematics should include units on teaching problem solving, instructional techniques, use of technology, and method courses for teaching remedial mathematics.

McKelvey and Others (1979) found that the outstanding problem faced by two-year college mathematics instructors (remedial and college-level) was teaching unmotivated students. Other problems were noted by over half of the instructors: having to cover much more material than students could absorb; coping with the deluge of remedial mathematics; lack of stimulation due to the elementary level and repetitiveness of courses; having too little time and energy available for professional activities outside the classroom; and lack of incentive or reward for professional growth. The investigators reported that most of the faculty members felt that today's students are less well-prepared than students were ten years ago. Many voiced concern over the serious reading problems of students enrolled in their courses.

Conclusion

This review of major recent studies of two-year college developmental mathematics programs shows that there has been much experimentation in curriculum offerings, course formats, and instructional approaches. These attempts at innovation add excitement to the field, serve as learning experiences for those involved, and, most important, have often resulted in the improvement of the mathematics program. Willcox has noted that "not all educational experiments are successful...not all teaching innovations endure...but [he finds] it hard to imagine any serious and carefully planned teaching innovation that will not contribute ultimately to better teaching. Even a teaching experience that is largely negative usually points toward a promising alternative..." (1977, p. 26).

Although many instructors are experimenting with new and presumably more effective methods of presenting developmental mathematics, the traditional classroom-lecture-text-book format remains the dominant mode of instruction. The use of traditional instructional methods, materials, assignments (see Beckwith, 1979), time constraints, and grading practices found in most developmental mathematics courses may be directly related to the traditional educational background and preparation of many instructors assigned to teach these courses.

A difficult challenge facing two-year colleges is to design developmental programs that will deal effectively with such problems as widespread avoidance of basic mathematics by students in need of such training, inadequate levels of achievement, and high attrition rates. In an effort to increase the effectiveness of their programs, colleges may wish to consider implementing the following recommendations. Instructors should be provided with special training in teaching remedial mathematics to community college students. This training should be available both in graduate school and as part of the college's in-service training program. Second, administrators should encourage instructors to develop new instructional methods and materials that can be used to improve the effectiveness of remedial courses. Third, the effectiveness of remedial mathematics courses should be closely monitored. And, most important, only those instructors who show strong motivation and interest in teaching remedial mathematics and who have the necessary competencies to do so effectively should be permitted to assume the responsibility for transmitting their knowledge and positive attitudes to students so in need of remedial mathematics.

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